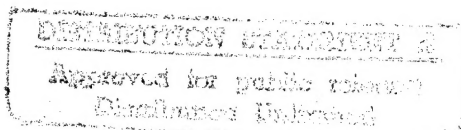


FINAL REPORT
NOVEMBER 1994

REPORT NO. 95-02

M24 WOODEN BOX WITH METAL LINER UNITED NATIONS (UN) PERFORMANCE ORIENTED PACKAGING (POP) TESTS

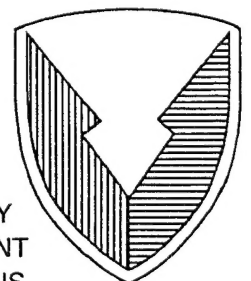


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U.S. Army Armament Research, Development
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U.S. ARMY DEFENSE AMMUNITION
CENTER AND SCHOOL

VALIDATION ENGINEERING DIVISION
SAVANNA, ILLINOIS 61074-9639

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22a. NAME OF RESPONSIBLE INDIVIDUAL JEROME H. KROHN			22b. TELEPHONE (Include Area Code) 815-273-8929		22c. OFFICE SYMBOL SMCAC-DEV

U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL
VALIDATION ENGINEERING DIVISION
SAVANNA, IL 61074-9639

REPORT NO. 95-02

M24 WOODEN BOX WITH METAL LINER UNITED NATIONS (UN)
PERFORMANCE ORIENTED PACKAGING (POP) TESTS

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PART 1

INTRODUCTION

A. BACKGROUND. The U.S. Army Defense Ammunition Center and School (USADACS), Validation Engineering Division (SMCAC-DEV), was tasked by U.S. Army Armament Research, Development and Engineering Center (ARDEC) to conduct United Nations (UN) Performance Oriented Packaging (POP) tests on M24 wooden boxes with metal liners which were manufactured in 1972 and 1982. UN POP tests were conducted to determine if these M24 wooden boxes were suitable to use to ship M6 solid propellant.

B. AUTHORITY. This program was conducted IAW mission responsibilities delegated by the U.S. Army Material Command (AMC), Logistics Support Activity Packaging, Storage, and Containerization Center (LOGSAPSCC). Effective 9 July 1993, the three-letter designator "DEV" was assigned for use when conducting UN POP tests. Effective 9 August 1994, this designation was included in the Joint Regulation AR 700-143, Performance Oriented Packaging of Hazardous Materials.

C. OBJECTIVE. To determine if older M24 wooden boxes with metal liners meet current UN POP shipping requirements and what packing group they should be assigned to.

D. CONCLUSION. The M24 wooden boxes with metal liners met UN POP Packing Group II requirements for M6 solid propellant. Several M24 containers were tested using the UN POP Packing Group I requirements and failed.

PART 2

NOVEMBER 1994

ATTENDEES

William R. Meyer
General Engineer
DSN 585-8090
815-273-8090

Director
U.S. Army Defense Ammunition Center
and School
ATTN: SMCAC-DEV
Savanna, IL 61074-9639

PART 3

UN POP TESTS

M24 Wooden Box With Metal Liner

U.S. Army Defense Ammunition Center and School

SMCAC-DEV, Savanna, IL 61074-9639

815-273-8090

W.R. Meyer

Test Report No.: 95-02

Service Code: DEV

Product NSN: 1376-00-854-6710

Nomenclature: M6 Propellant (Flake)

Shipping Name: Smokeless Powder

UN ID No.: 0161

Hazard Class: 1.3C

Packing Group: II

Physical State: Solid

NALC/DODAC: CX52

CAA No.: n/a

EX No.: 8801-544

CFR 49 Packaging Method: Part 173.62, Packing Group II, Method E-22

Net Explosive Weight: 66.4 kg (146 pounds)

DESCRIPTION OF PACKAGINGS TO BE TESTED

EXTERIOR CONTAINER

Exterior Container: Wooden Box

CFR 49 Reference Number: Part 173.62, Package Group 2, Method E-22

UN Code: 4C1

NSN Exterior Container: 8140-00-827-6263

Specifications: Mil-B-2427F (PA)

Mil-B-2427D (MU)

Type 1 Class 1 Grade A

Net Quantity Weight: 66.4 kg (146 pounds)

Tested Gross Weight: 93.2 kg (205 pounds)

Interior Dimensions: L-16.25" X W-12.0" X H-27.0"

Manufacturer: Penna Pacific Corporation Gate Wood Products Incorporated
Pennbox Division Parkersburg, WV
Warmingster, PA

Year Container Manufactured: October 1972 and November 1982

Drawing Number(s): 76-4-46, Rev 8
76-4-46A, Rev 4
76-4-47, Rev 7

Cushioning: None

Closure: Metal spider lid (twist lock)

INTERMEDIATE CONTAINER

Intermediate Container Description: Copper Liner

Specification Number: MIL-B2427-F
MIL-B2427-D
Type 1, Class 1, Grade A

Container NSN: 8140-00-827-6263

Intermediate Container Cushioning: None

Intermediate Container Closure Method: Metal spider lid (twist lock)

Intermediate Container Dimensions: L-16.0", W-11.75", H-26.75"

Number Of Intermediate Containers: One

UNIT CONTAINER

Unit Container Description: N/A

Unit Container Specification: N/A

Unit Container NSN: N/A

Unit Container Cushioning: N/A

Unit Container Closure Method: N/A

Unit Container Dimensions: N/A

Number of Unit Containers: N/A

SPECIAL NOTE

All exterior and intermediate containers must be inspected prior to use. Inspect for physical damage and structural integrity of the containers.

SUPPLEMENTAL INFORMATION

Permitted Transportation Modes: Commercial truck and rail, military truck and rail, IMDG

Specific Gravity: N/A

Hydrostatic Test Pressure Applied: N/A

Leakproofness Test Pressure Applied: N/A

TEST PROCEDURES

Tests Conducted	Test Method	Test Results
(1) Pre-Conditioning (fiberboard)	Part 178.602	N/A
(2) Drop Test	Part 178.603(e)(1)(ii)	Pass
(3) Leakproofness Test	Part 178.604	N/A
(4) Hydrostatic Pressure Test	Part 178.605	N/A
(5) Stacking Test (1,300 lbs)	Part 178.606(c)(1)	Pass
(6) Vibration Test	Part 178.608(b)(3)	Pass

POP Marking

POP Marking that is applicable to this test report

u 4C1/Y66.4/S/82

n USA/DOD/DEV

CERTIFICATION

Unless expressly stated to the contrary, we certify that all of the above applicable tests have been performed in strict conformance to CFR 49, Subpart M, Parts 178.600 - 178.608. Based on the successful test results shown above, this container is deemed suitable for transport of the hazardous material described herein, provided that maximum tested weights and quantities are not exceeded and the packaging is assembled as tested. The use of other packaging methods or components may make this test invalid.

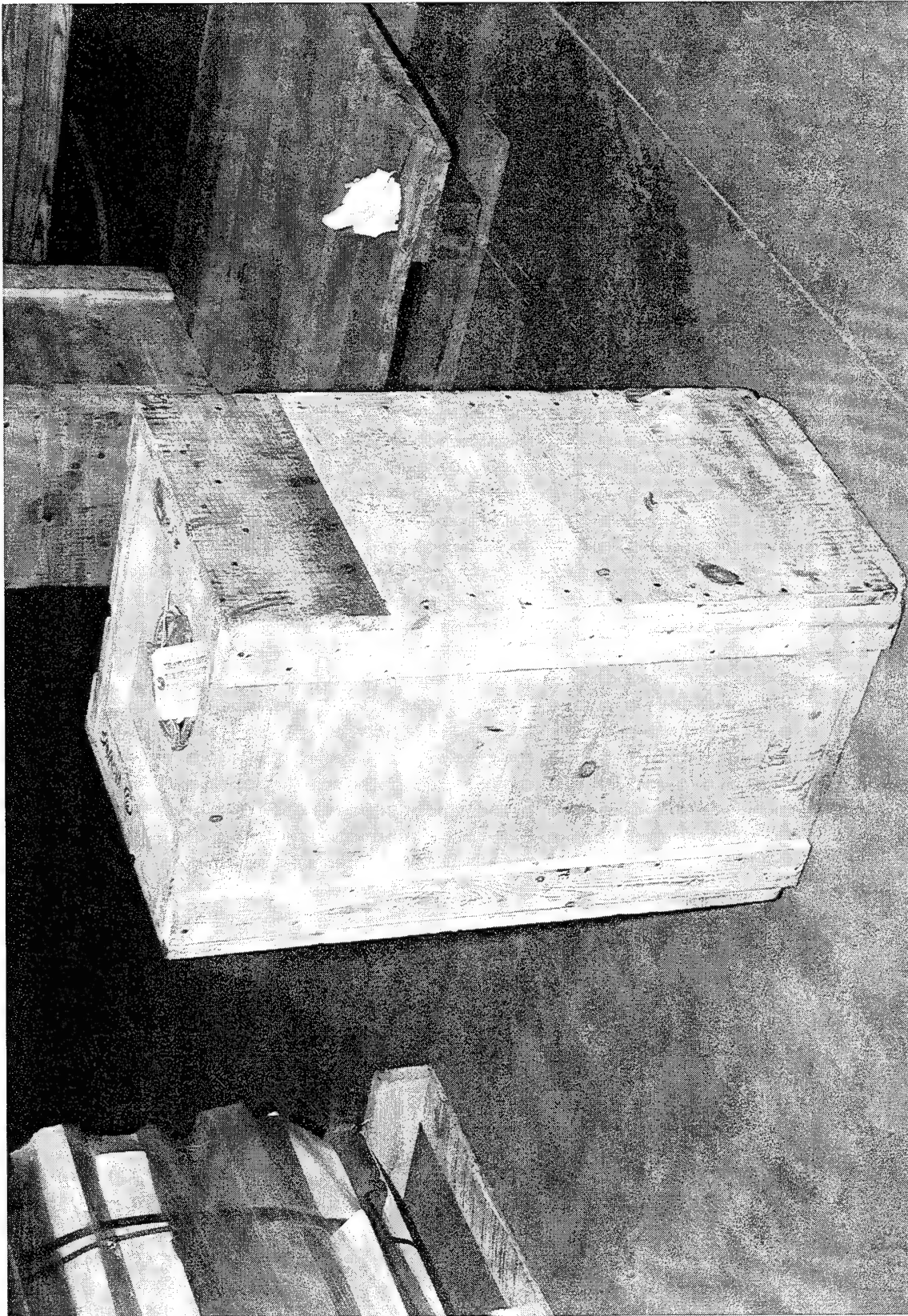
PREPARED BY: William R. Meyer DATE: 31-May-95
WILLIAM R. MEYER
Test Engineer

SUBMITTED BY: Jerome H. Krohn DATE: 31 May '95
JEROME H. KROHN
Chief, Validation Engineering Division

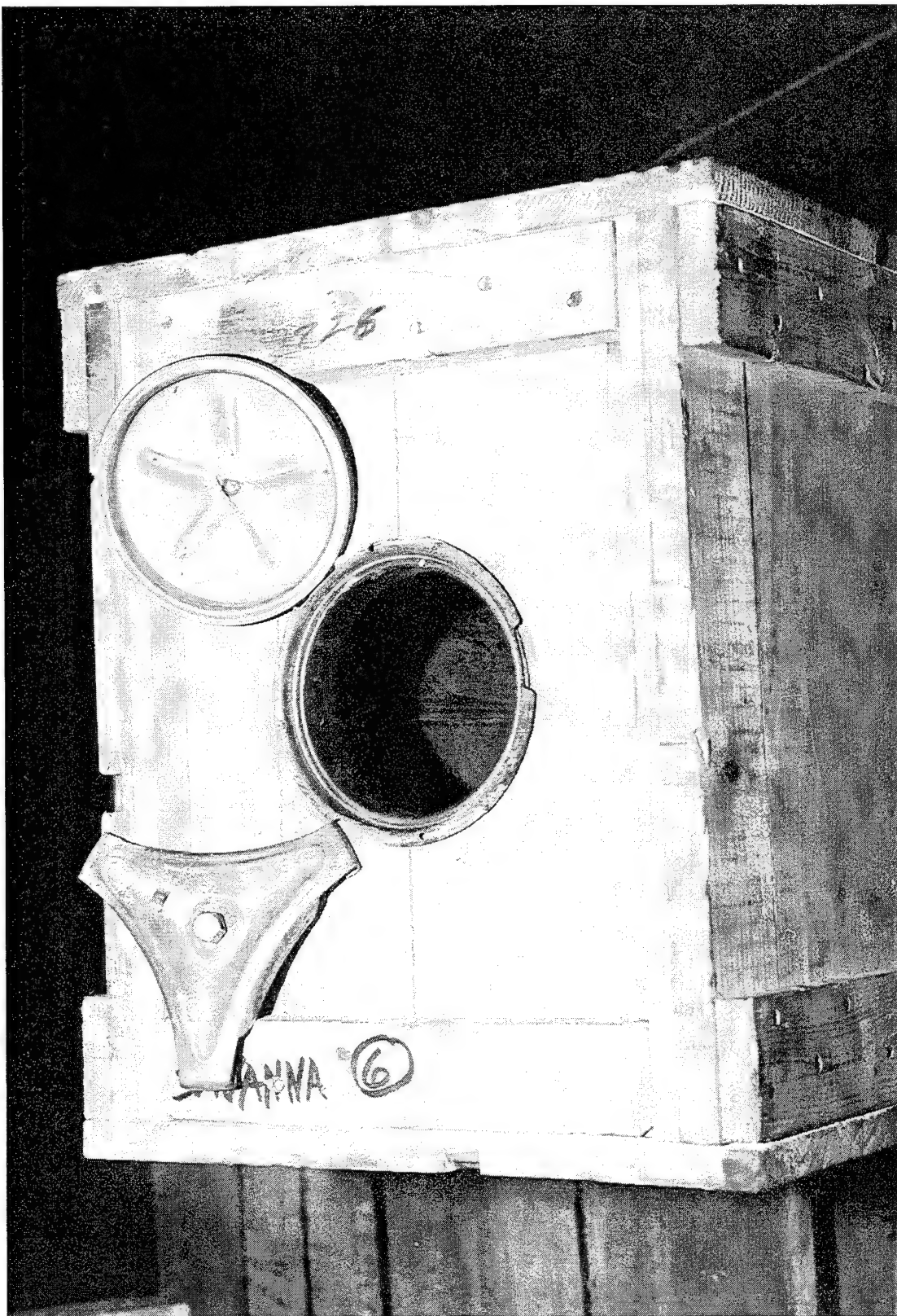
APPROVED BY: Thomas J. Michels DATE: 31 May 95
THOMAS J. MICHELS
Acting Chief, Logistics Engineering Office

PART 4

PHOTOGRAPHS



	U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL - SAVANNA, IL
PHOTO NO. AO317-SCN95-22-312: This photo shows an overall view of the M24 wooden box with metal liner used for UN POP testing.	

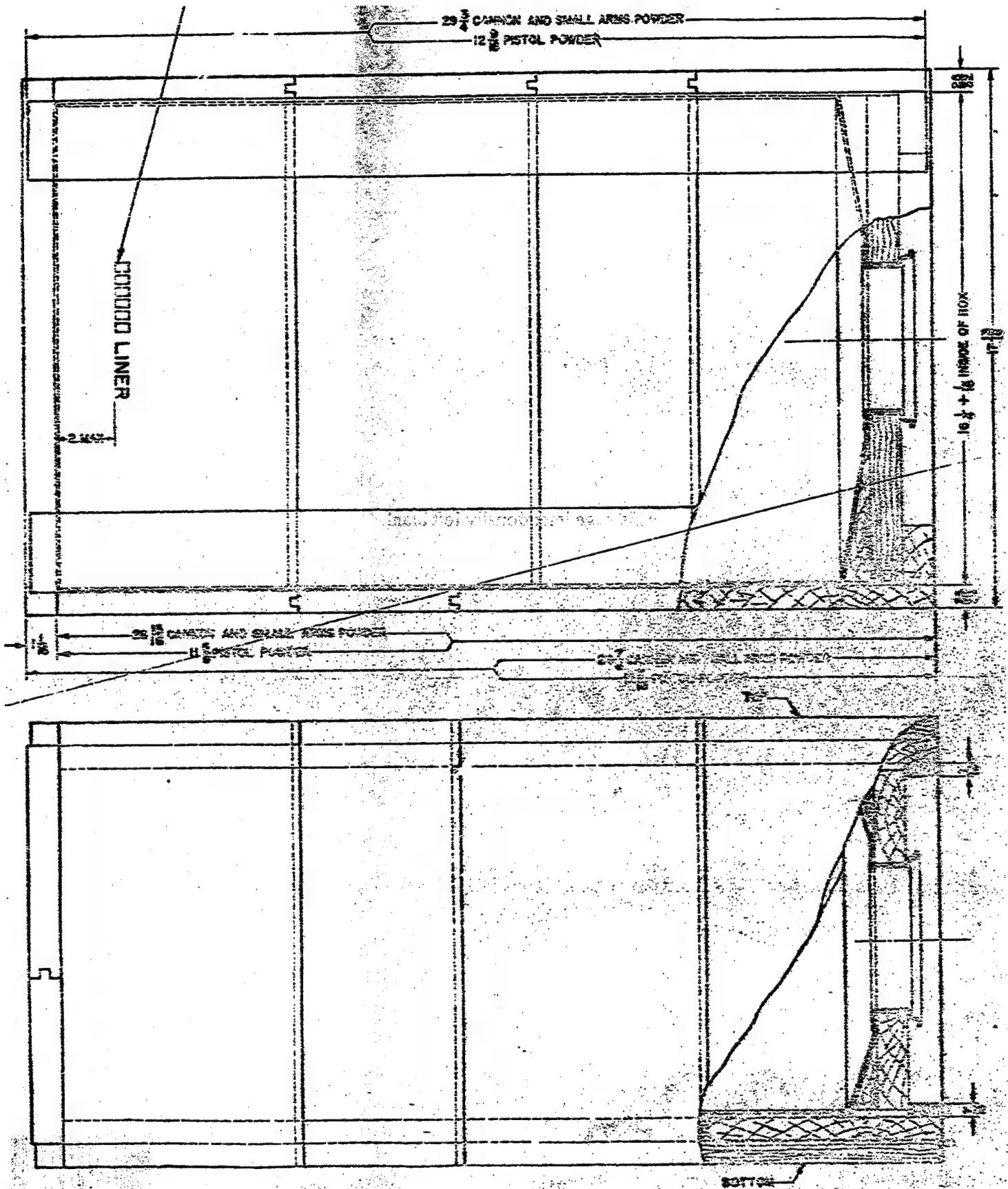


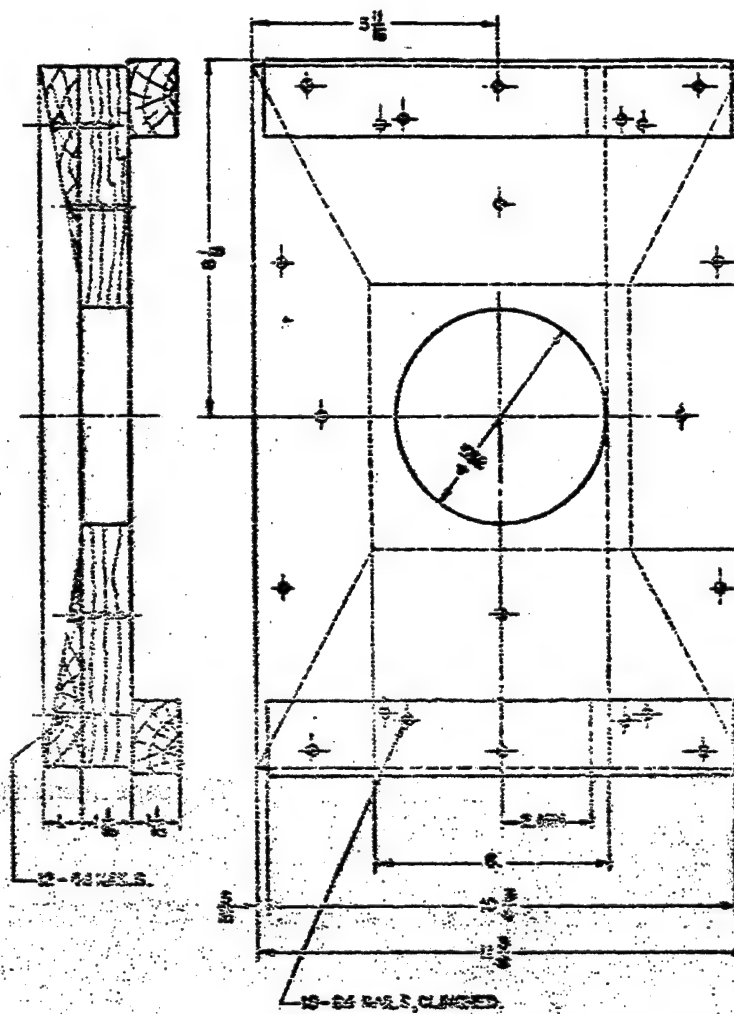
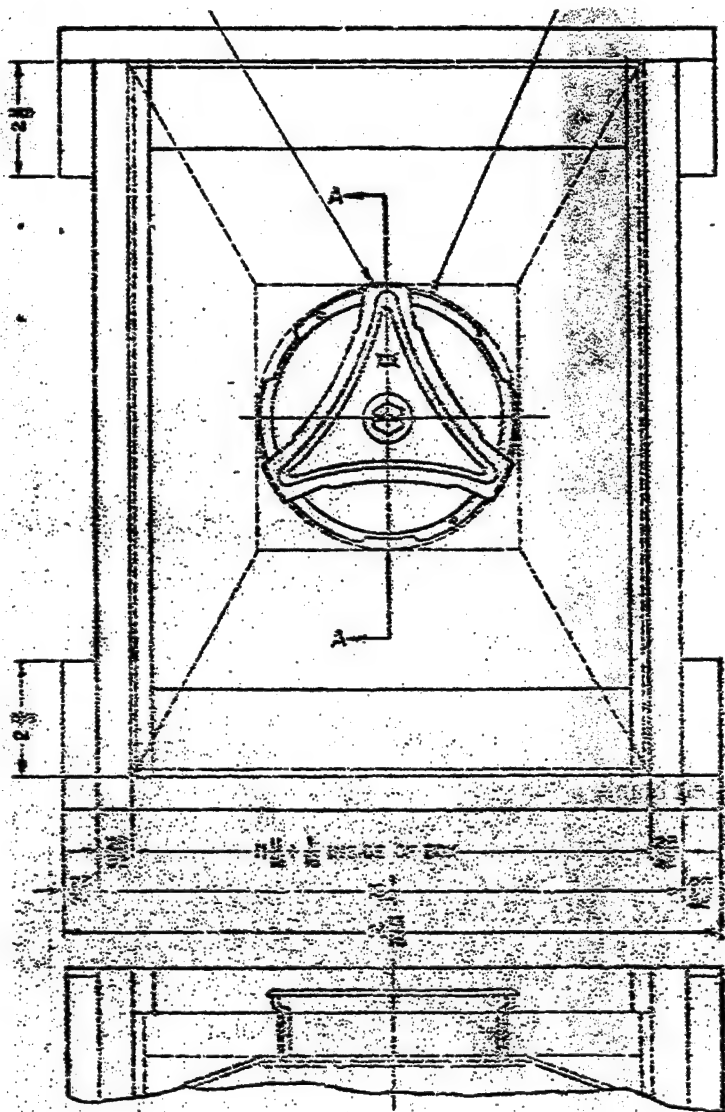
	U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL - SAVANNA, IL	
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PHOTO NO. A0317-SCN95-22-313: This photo shows a closeup view of the M24 metal spider lid (twist lock).

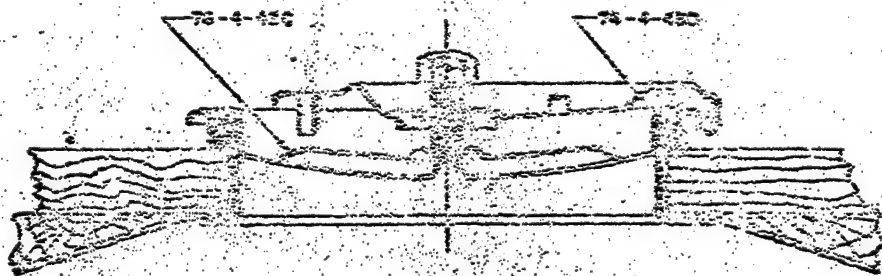
PART 5

DRAWING

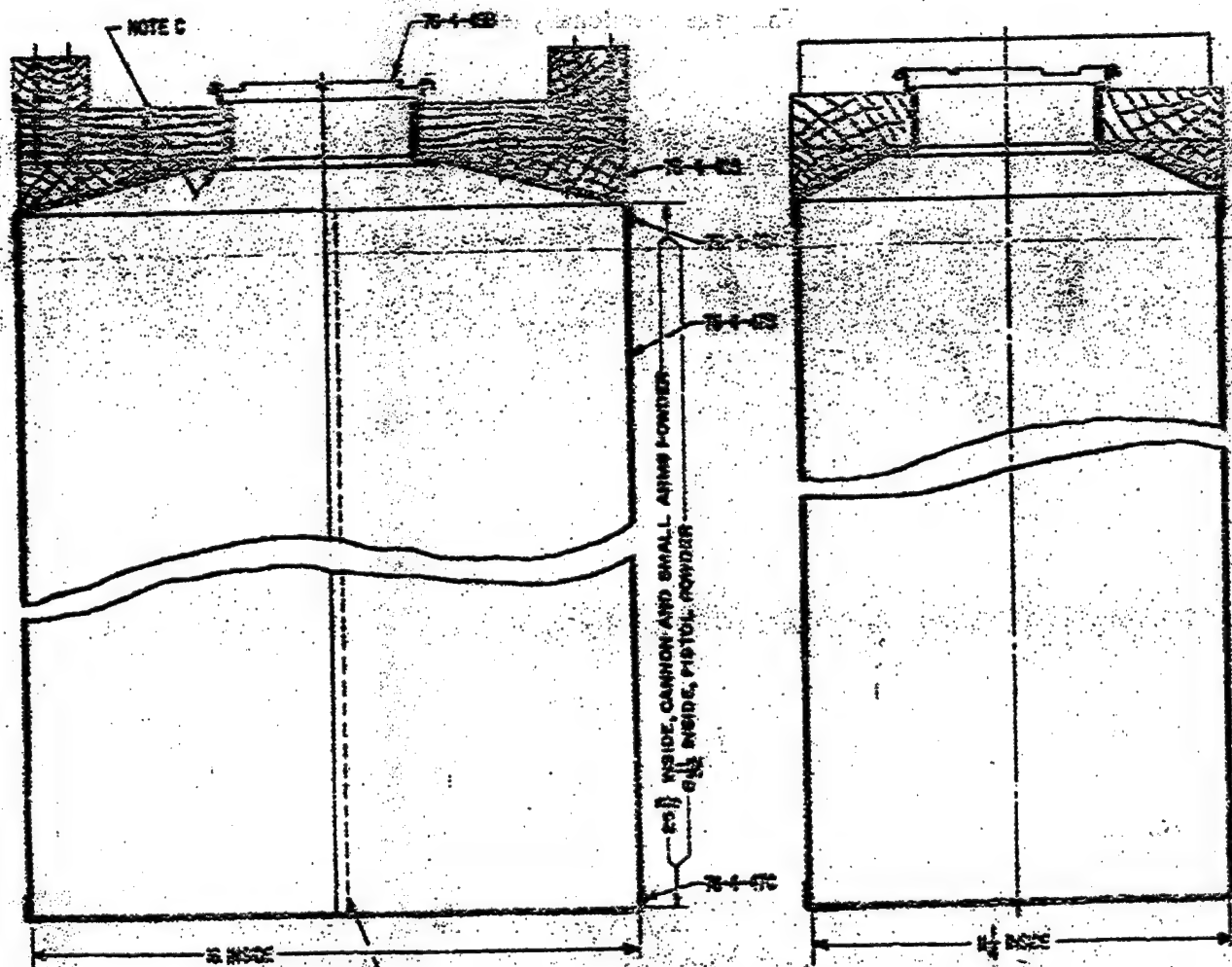
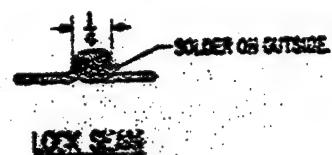
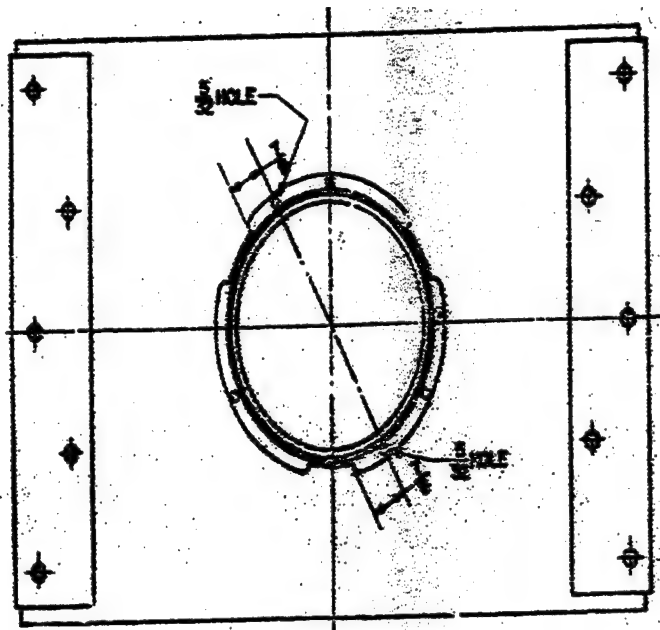




COVER PLATE 76-4-435



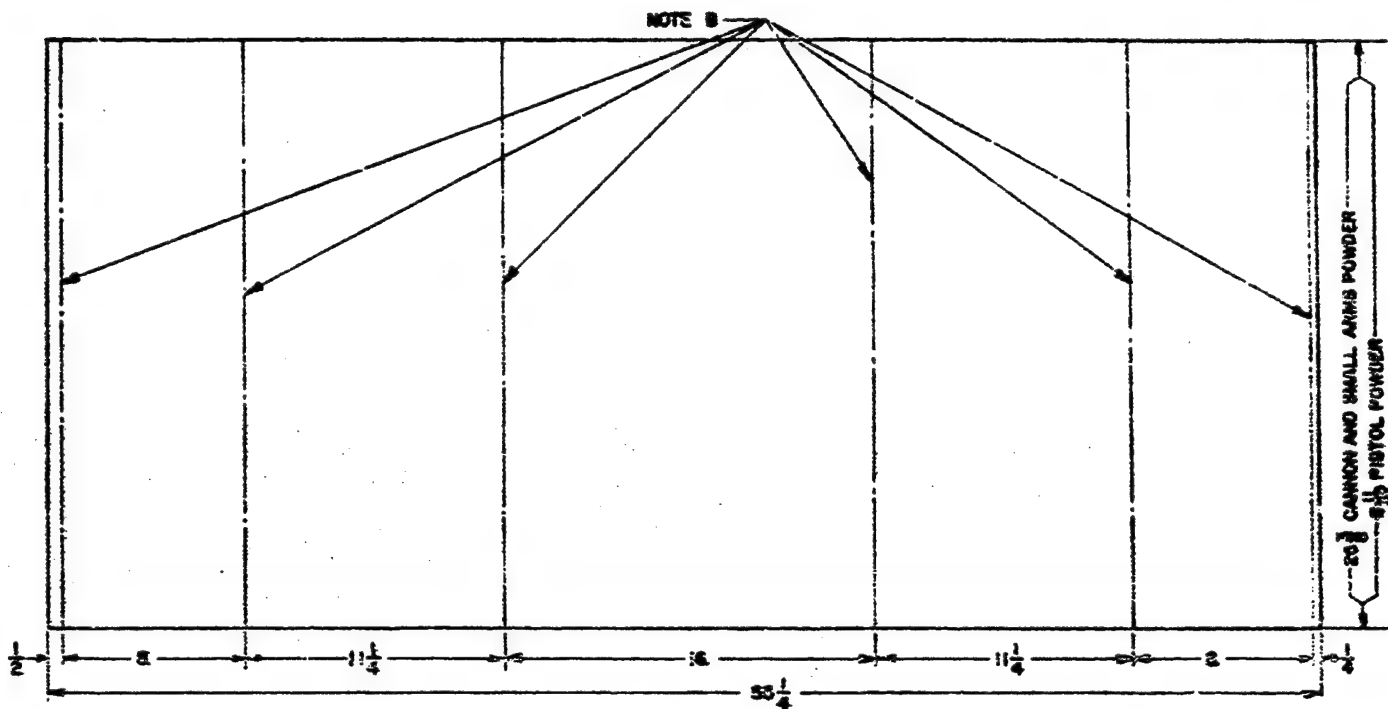
5/16-18 UNF-2B
S-1



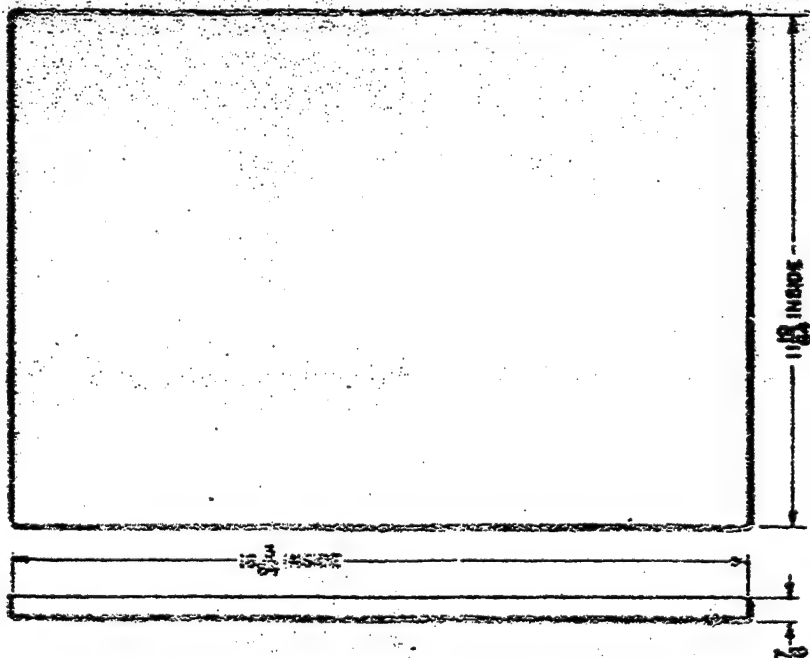
NOTE F

LESS 70-4-42A7

NOTE A



NOTE C
THIS MODEL IS A REPRESENTATION OF
A MODEL, NOT A SCALE MODEL. IT IS NOT TO BE USED FOR
ANY PURPOSES OTHER THAN TO ILLUSTRATE THE GENERAL
APPEARANCE OF THE MODEL.



PART 6

APPENDIX

Subpart M

TESTING OF NON-BULK PACKAGINGS AND PACKAGES

Sec. 178.600 Purpose and scope.

This subpart prescribes certain testing requirements for performance-oriented packagings identified in Subpart L of this part.

1 Sec. 178.601 General requirements.

(a) **General.** The test procedures prescribed in this subpart are intended to ensure that packages containing hazardous materials can withstand normal conditions of transportation and are considered minimum requirements. Each packaging must be manufactured and assembled so as to be capable of successfully passing the prescribed tests and of conforming to the requirements of § 173.24 of this subchapter at all times while in transportation.

(b) **Responsibility.** It is the responsibility of the packaging manufacturer and the person who offers a hazardous material for transportation, to the extent that assembly functions including final closure are performed by the latter to assure that each package is capable of passing the prescribed tests.

(c) **Definitions.** For the purpose of this subpart:

(1) **Design qualification testing** is the performance of the drop, leakproofness, hydrostatic pressure, stacking, and cooperage tests, as applicable, prescribed in §§ 178.603, 178.604, 178.605, 178.606, or 178.607, respectively, for each new or different packaging, at the start of production of that packaging.

(2) **Periodic retesting** is the performance of the drop, leakproofness, hydrostatic pressure, and stacking tests, as applicable, prescribed in §§ 178.603, 178.604, 178.605, or 178.606, respectively, at the frequency specified in 178.601(e) of this subpart.

(3) **Production testing** is the performance of the leakproofness test prescribed in § 178.604 of this subpart on each single or composite packaging intended to contain a liquid.

(4) **A different packaging** is one that differs (i.e. is not identical) from a previously produced packaging in structural design, size, material of construction, wall thickness or manner of construction but does not include:

(i) A packaging which differs only in surface treatment;

(ii) A combination packaging which differs only in that the outer packaging has been successfully tested with different inner packagings. A variety of such inner packagings may be assembled in this outer packaging without further testing;

(iii) A plastic packaging which differs only with regard to additives which conform to §§ 178.509(b)(4) or (5) of this part;

(iv) A combination packaging with inner packagings conforming to the provisions of paragraph (g) of this section; or

(v) Packagings which differ from the design type only in their lesser design height.

(d) Design qualification testing. The packaging manufacturer shall achieve successful test results for the design qualification testing at the start of production of each new or different packaging.

(e) Periodic retesting. The packaging manufacturer shall achieve successful test results for the periodic retesting at intervals established by the manufacturer of sufficient frequency to ensure that each packaging produced by the manufacturer is capable of passing the design qualification tests. Changes in retest frequency are subject to the approval of the Associate Administrator for Hazardous Materials Safety. For single or composite packagings, the periodic retests must be conducted at least once every 12 months. For combination packagings, the periodic retests must be conducted at least once every 24 months.

(f) Test samples. The manufacturer shall conduct the design qualification and periodic tests prescribed in this subpart using random samples of packagings, in the numbers specified in the appropriate test section. In addition, the leakproofness test, when required, shall be performed on each packaging produced by the manufacturer, and each packaging prior to reuse under § 173.28 of this subchapter, by the reconditioner.

(g) Selective testing. The selective testing of packagings that differ only in minor respects from a tested type is permitted as described in this section. For air transport, packagings must comply with § 173.27(c)(1) and (c)(2) of this subchapter.

(1) Selective testing of combination packagings, Variation 1. Variations are permitted in inner packagings of a tested combination package, without further testing of the package, provided an equivalent level of performance is maintained, as follows:

(i) Inner packagings of equivalent or smaller size may be used provided -

(A) The inner packagings are of similar design to the tested inner packagings (i.e. shape - round, rectangular, etc.);

- (B) The material of construction of the inner packagings (glass, plastic, metal, etc.) offers resistance to impact and stacking forces equal to or greater than that of the originally tested inner packaging;
 - (C) The inner packagings have the same or smaller openings and the closure is of similar design (e.g., screw cap, friction lid, etc.);
 - (D) Sufficient additional cushioning material is used to take up void spaces and to prevent significant movement of the inner packagings;
 - (E) Inner packagings are oriented with the outer packing in the same manner as in the tested package; and,
 - (F) The gross mass of the package does not exceed that originally tested.
- (ii) A lesser number of the tested inner packagings, or of the alternative types of inner packagings identified in paragraph (g)(1)(i) of this section, may be used provided sufficient cushioning is added to fill void space(s) and to prevent significant movement of the inner packagings.
- (2) **Selective testing of combination packagings, Variation 2.** Inner packagings of any type, for solids or liquids, may be assembled and transported without testing in an outer packaging under the following conditions.
- (i) The outer packaging must have been successfully tested in accordance with § 178.603 of this subpart, with fragile (e.g., glass) inner packagings at the Packing Group 1 drop height;
 - (ii) The total combined gross mass of inner packagings may not exceed one-half the gross mass of inner packagings used for the drop test;
 - (iii) The thickness of cushioning material between inner packagings and between inner packagings and the outside of the packaging may not be reduced below the corresponding thickness in the originally tested packaging; and when a single inner packaging was used in the original test, the thickness of cushioning between inner packagings may not be less than the thickness of cushioning between the outside of the packaging and the inner packaging in the original test. When either fewer or smaller inner packagings are used (as compared to the inner packagings used in the drop test), sufficient additional cushioning material must be used to take up void spaces.
 - (iv) The outer packaging must have successfully passed the stacking test set forth in § 178.606 of this subpart when empty, i.e., without either inner packagings or cushioning

materials. The total mass of identical packages must be based on the combined mass of inner packagings used for the drop test;

- (v) Inner packagings containing liquids must be completely surrounded with a sufficient quantity of absorbent material to absorb the entire liquid contents of the inner packagings;
- (vi) When the outer packaging is intended to contain inner packagings for liquids and is not leakproof, or is intended to contain inner packagings for solids and is not sift-proof, a means of containing any liquid or solid contents in the event of leakage must be provided in the form of a leakproof liner, plastic bag, or other equally efficient means of containment; and
- (vii) Packagings must be marked in accordance with 178.503 of this part as having been tested to Packing Group 1 performance for combination packagings. The marked maximum gross mass may not exceed the sum of the mass of the outer packaging plus one-half the mass of the filled inner packagings of the tested combination packaging. In addition, the marking required by 178.503(a)(2) of this part must include the letter "V."

(3) **Variation 3.** Packagings other than combination packagings which are produced with reductions in external dimensions (i.e., length, width or diameter) of up to 25 percent of the dimensions of a tested packaging may be used without further testing provided an equivalent level of performance is maintained. The packagings must, in all other respects (including wall thicknesses), be identical to the tested design-type. The marked gross mass (when required) must be reduced in proportion to the reduction in volume.

(4) **Variation 4.** Variations are permitted in outer packagings of a tested design-type combination packaging, without further testing, provided an equivalent level of performance is maintained, as follows:

- (i) Each external dimension (length, width and height) is less than or equal to the corresponding dimension of the tested design-type;
- (ii) The structural design of the tested outer packaging (i.e. methods of construction, materials of construction, strength characteristics of materials of construction, method of closure and material thicknesses) is maintained;
- (iii) The inner packagings are identical to the inner packagings used in the tested design type except that their size and mass may be less; and they are oriented within the outer packaging in the same manner as in the tested packaging;
- (iv) The same type or design of absorbent materials, cushioning materials and any other components necessary to contain and protect inner packagings, as used in the tested design

type, are maintained. The thickness of cushioning material between inner packagings and between inner packagings and the outside of the packaging may not be less than the thickness in the tested design type packaging; and

- (v) Sufficient additional cushioning material is used to take up void spaces and to prevent significant movement of the inner packagings. An outer packaging qualifying for use in transport in accordance with all of the above conditions may also be used without testing to transport inner packagings substituted for the originally tested inner packagings in accordance with the conditions set out in Variation 1 in paragraph (g)(1) of this section.

(5) Variation 5. Single packagings (i.e., non-bulk packagings other than combination packaging(s), that differ from a tested design type only to the extent that the closure device or gasketing differs from that used in the originally tested design type, may be used without further testing, provided an equivalent level of performance is maintained, subject to the following conditions (the qualifying tests):

- (i) A packaging with the replacement closure devices or gasketing must successfully pass the drop test specified in § 178.602 in the orientation which most severely tests the integrity of the closure or gasket;
- (ii) When intended to contain liquids, a packaging with the replacement closure devices or gasketing must successfully pass the leakproofness test specified in § 178.603, the hydrostatic pressure test specified in § 178.605, and the stacking test specified in 178.606. Replacement closures and gasketings qualified under the above test requirements are authorized without additional testing for packagings described in paragraph (g)(3) of this section. Replacement closures and gasketings qualified under the above test requirements also are authorized without additional testing for different tested design packagings of the same type as the originally tested packaging, provided the original design type tests are more severe or comparable to tests which would otherwise be conducted on the packaging with the replacement closures or gasketings. (For example: The packaging used in the qualifying tests has a lesser packaging wall thickness than the packaging with replacement closure devices or gasketing; the gross mass of the packaging used in the qualifying drop test equals or exceeds the mass for which the packaging with replacement closure devices or gasketing was tested; the packaging used in the qualifying drop test was dropped from the same or greater height than the height from which the packaging with replacement closure devices or gasketing was dropped in design type tests; and the specific gravity of the substance used in the qualifying drop test was the same or greater than the specific gravity of the liquid used in the design type tests of the packaging with replacement closure devices or gasketing.)

(6) The provisions in Variations 1, 2, and 4 in paragraphs (g)(1), (2), and (4) of this section for combination packagings may be applied to packagings containing articles, where the provisions for inner packagings are applied analogously to the articles. In this case, inner packagings need not comply with § 173.27(c)(1) and (c)(2) of this subchapter.

(7) **Approval of selective testing.** In addition to the provisions of § 178.601(g)(2) of this subpart, the Associate administrator for Hazardous Materials Safety may approve the selective testing of packagings that differ only in minor respects from a tested type.

(h) **Approval of equivalent packagings.** A packaging having specifications different from those in §§ 178.505-178.523 of this part, or which is tested using methods or test intervals other than those specified in Subpart M of this Part, may be used if approved by the Associate Administrator for Hazardous Materials Safety. Such packagings must be shown to be equally effective, and testing methods used must be equivalent.

(i) **Proof of compliance.** Notwithstanding the periodic retest intervals specified in paragraph (e) of this section, the Associate Administrator for Hazardous Materials Safety may at any time require demonstration of compliance by a manufacturer, through testing in accordance with this subpart, that packagings meet the requirements of this subpart. As required by the Associate Administrator for Hazardous Materials Safety, the manufacturer shall either-

(1) Conduct performance tests, or have tests conducted by an independent testing facility, in accordance with this subpart; or

(2) Supply packagings, in quantities sufficient to conduct tests in accordance with this subpart, to the Associate Administrator for Hazardous Materials Safety or a designated representative of the Associate Administrator.

(j) **Coatings.** If an inner treatment or coating of a packaging is required for safety reasons, the manufacturer shall design the packaging so that the treatment or coating retains its protective properties even after withstanding the tests prescribed by this subpart.

(k) **Record retention.** The person who certifies the tested design type shall-

(1) Keep records of design qualification tests, including specific types, dates, locations, packaging specifications, test specifics (drop heights, hydrostatic pressures, etc.), results, and test operators' names or name of person responsible for testing, for each packaging at each location where that packaging is manufactured and at each location where design qualification tests are conducted, as long as the packaging is produced and for at least two years thereafter.

(2) Keep records of periodic retests, including specific types, dates, locations, packaging specifications, test specifics (drop heights, hydrostatic pressures, etc.), results, and test

operator's names or name of person responsible for testing, at each location where that packaging is manufactured and at each location where periodic tests are conducted, until such tests are successfully performed again and for at least two years from the date of each test; and

(3) Make all records of design qualification tests and periodic retests available for inspection by a representative of the Department upon request.

1] Sec. 178.602 Preparation of packagings and packages for testing.

(a) Except as otherwise provided in this subchapter, each packaging and package must be closed in preparation for testing and tests must be carried out in the same manner as if prepared for transportation, including inner packagings in the case of combination packagings.

(b) For the drop and stacking test, inner and single-unit receptacles must be filled to not less than 95 percent of maximum capacity (see § 171.8 of this subchapter) in the case of solids and not less than 98 percent maximum capacity in the case of liquids. The material to be transported in the packagings may be replaced by a non-hazardous material, except for chemical compatibility testing or where this would invalidate the results of the tests.

(c) If the material to be transported is replaced for test purposes by non-hazardous material, the material used must be of the same or higher specific gravity as the material to be carried, and its other physical properties (grain, size, viscosity) which might influence the results of the required tests must correspond as closely as possible to those of the hazardous material to be transported. Water may also be used for the liquid drop test under the conditions specified in § 178.603(d)(2) of this subpart. It is permissible to use additives, such as bags of lead shot, to achieve the requisite total package mass, so long as they are placed so that the test results are not affected.

(d) Paper or fiberboard packagings must be conditioned for at least 24 hours immediately prior to testing in an atmosphere maintained-

(1) At 50 percent \pm 2 percent relative humidity, and at a temperature of $23^{\circ}\text{C} \pm 2^{\circ}\text{C}$ ($73^{\circ}\text{F} \pm 4^{\circ}\text{F}$). Average values should fall within these limits. Short-term fluctuations and measurement limitations may cause individual measurements to vary by up to \pm 5 percent relative humidity without significant impairment of test reproducibility;

(2) At 65 percent \pm 2 percent relative humidity, and at a temperature of $20^{\circ}\text{C} \pm 2^{\circ}\text{C}$ ($68^{\circ}\text{F} \pm 4^{\circ}\text{F}$), or $27^{\circ}\text{C} \pm 2^{\circ}\text{C}$ ($81^{\circ}\text{F} \pm 4^{\circ}\text{F}$). Average values should fall within these limits. Short-term fluctuations and measurement limitations may cause individual measurements

to vary by up to ± 5 percent relative humidity without significant impairment of test reproducibility; or

(3) For testing at periodic intervals only (i.e., other than initial design qualification testing), at ambient conditions.

(e) Except as otherwise provided, each packaging must be closed in preparation for testing in the same manner as if repaired for actual shipment. All closures must be installed using proper techniques and torques.

(f) Bung-type barrels made of natural wood must be left filled with water for at least 24 hours before the tests.

1 Sec. 178.603 Drop Test.

(a) **General.** The drop test must be conducted for the qualification of all packaging design types and performed periodically as specified in § 178.601(e). The number of drops required and the packages' orientations are as follows:

(b) **Exceptions.** For testing of single or composite packagings constructed of stainless steel, nickel, or monel at periodic intervals only (i.e., other than design qualification testing), the drop test may be conducted with two samples, one sample each for the two drop orientations. These samples may have been previously used for the hydrostatic pressure or stacking test. Exceptions for the number of steel and aluminum packaging samples used for conducting the drop test are subject to the approval of the Associate Administrator for Hazardous Materials Safety.

(c) **Special preparation of test samples for the drop test.** Testing of plastic drums, jerricans, and boxes, composite packagings with inner plastic receptacles, and of combination packagings with inner plastic receptacles, other than expanded plastic boxes and bags, must be carried out when the temperature of the test sample and its contents has been reduced to $-18^{\circ}\text{C}(0^{\circ}\text{F})$ or

Packaging	No. of tests	Drop orientation of samples
Steel drums, Aluminum drums, Metal drums (other than steel or aluminum), Steel jerricans, Plywood drums, Wooden barrels, Fiber drums, Plastic drums and jerricans, Composite packagings which are in the shape of a drum.	Six - (three for each drop)	First drop (using three samples): The package must strike the target diagonally on the chime or, if the packaging has no chime, on the circumferential seam or an edge. Second drop (using the other three samples): The package must strike the target on the weakest part not tested by the first drop, for example a closure or, for some cylindrical drums, the welded longitudinal seam of the drum body.
Boxes of natural wood, Plywood boxes, Reconstituted wood boxes, Fiberboard boxes, Plastic boxes, Steel or aluminum boxes, Composite packagings which are in the shape of a box.	Five - (one for each drop)	First drop: Flat on the bottom (using the first sample). Second drop: Flat on the top (using the second sample). Third drop: Flat on the long side (using the third sample). Fourth drop: Flat on the short side (using the fourth sample). Fifth drop: On a corner (using the fifth sample).
Bags - single-ply with a side seam.	Three - (three drops per bag) . .	First drop: Flat on a wide face (using all three samples). Second drop: Flat on a narrow face (using all three samples). Third drop: On an end of the bag (using all three samples).

lower. Test liquids shall be kept in the liquid state if necessary, by the addition of anti-freeze. Test samples prepared in this way are not required to be conditioned in accordance with § 178.602(d).

(d) Target. The target must be a rigid, non-resilient, flat and horizontal surface.

(e) Drop height. Drop heights, measured as the vertical distance from the target to the lowest point on the package, must be determined as follows:

(1) For solids and liquids, if the test is performed with the solid or liquid to be transported or with a non-hazardous material having essentially the same physical characteristic, the drop height must be determined according to packing group, as follows:

(i) Packing Group I: 1.8 m (5.9 feet).

(ii) Packing Group II: 1.2 m (3.9 feet).

(iii) Packing Group III: 0.8 m (2.6 feet).

(2) For liquids, if the test is performed with water-

(i) Where the materials to be carried have a specific gravity not exceeding 1.2, drop height must be determined according to packing group, as follows:

(A) Packing Group I: 1.8 m (5.9 feet).

(B) Packing Group II: 1.2 m (3.9 feet).

(C) Packing Group III: 0.8 m (2.6 feet).

(ii) Where the materials to be transported have a specific gravity exceeding 1.2, the drop height must be calculated on the basis of the specific gravity (SG) of the material to be carried, rounded up to the first decimal, as follows:

(A) Packing Group I: $SG \times 1.5$ m (4.9 feet).

(B) Packing Group II: $SG \times 1.0$ m (3.3 feet).

(C) Packing Group III: $SG \times 0.67$ m (2.2 feet).

(f) Criteria for passing the test. A package is considered to successfully pass the drop tests if for each sample tested-

(1) For receptacles containing liquid, each receptacle does not leak when equilibrium has been reached between the internal and external pressures;

(2) For removable head drums for solids, the entire contents are retained by an inner packaging (e.g., a plastic bag) even if the closure on the top head of the drum is no longer sift-proof;

(3) For a bag, neither the outermost ply nor an outer packaging exhibits any damage likely to adversely affect safety during transport;

(4) For a composite or combination packaging, there is no damage to the outer packaging likely to adversely affect safety during transport, and there is no leakage of the filling substance from the inner packaging;

(5) For a drum, jerrican or bag, any discharge from a closure is slight and ceases immediately after impact with no further leakage; and

(6) No rupture is permitted in packagings for materials in Class 1 which would permit spillage of loose explosive substances or articles from the outer packaging.

1] Sec. 178.604 Leakproofness test.

(a) **General.** The leakproofness test must be performed with compressed air or other suitable gases on all packagings intended to contain liquids, except that:

(1) The inner receptacle of a composite packaging may be tested without the outer packaging provided the test results are not affected; and

(2) This test is not required for inner packagings of combination packagings.

(b) Number of packagings to be tested-

(1) **Production testing.** All packagings subject to the provisions of this section must be tested and must pass the leakproofness test;

(i) Before they are first used in transportation; and

(ii) Prior to reuse, when authorized for reuse by § 173.28 of this subchapter.

(2) **Design qualification and periodic testing.** Three samples of each different packaging must be tested and must pass the leakproofness test. Exceptions for the number of samples used in conducting the leakproofness tests are subject to the approval of the Associate Administrator for Hazardous Materials Safety.

(c) Special preparation-

(1) For design qualification and periodic testing, packagings must be tested with closures in place. For production testing, packagings need not have their closures in place. Removable heads need not be installed during production testing.

(2) For testing with closures in place, vented closures must either be replaced by similar non-vented closures or the vent must be sealed.

(d) Test method. The packaging must be restrained under water while an internal air pressure is applied; the method of restraint must not affect the results of the test. The test must be conducted for a period of time sufficient to pressurize the interior of the packaging to the specified air pressure and to determine if there is leakage of air from the packaging. Other methods, at least equally effective, may be used in accordance with Appendix B of this part.

(e) Pressure applied. An internal air pressure (gauge) must be applied to the packaging as indicated for the following packaging groups;

(1) Packing Group I: Not less than 30 kPa (4 psi).

(2) Packing Group II: Not less than 20 kPa (3 psi).

(3) Packing Group III: Not less than 20 kPa (3 psi).

(f) Criteria for passing the test. A packaging passes the test if there is no leakage of air from the packaging.

1 Sec. 178.605 Hydrostatic pressure test.

(a) General. The hydrostatic pressure test must be conducted for the qualification of all metal, plastic, and composite packaging design types intended to contain liquids and be performed periodically as specified in § 178.601(e). This test is not required for inner packagings of combination packagings. For internal pressure requirements for inner packagings of combination packagings intended for transportation by aircraft, see § 173.27(c) of this subchapter.

(b) Number of test samples. Three test samples are required for each different packaging. For packagings constructed of stainless steel, monel, or nickel, only one sample is required for periodic retesting of packagings. Exceptions for the number of aluminum and steel sample packagings used in conducting the hydrostatic pressure test are subject to the approval of the Associate Administrator of Hazardous Materials Safety.

(c) Special preparation of receptacles for testings. Vented closures must either be replaced by similar non-vented closures or the vent must be sealed.

(d) **Test method and pressure to be applied.** Metal packagings and composite packagings other than plastic (e.g., glass, porcelain or stoneware), including their closures, must be subjected to the test pressure for 5 minutes. Plastic packagings and composite packagings (plastic material), including their closures, must be subjected to the test pressure for 30 minutes. This pressure is the one to be marked as required in § 178.503(a)(5) of this part. The receptacles must be supported in a manner that does not invalidate the test. Then test pressure must be applied continuously and evenly, and it must be kept constant throughout the test period. The hydraulic pressure (gauge) applied, taken at the top of the receptacle, and determined by any one of the following methods must be:

(1) Not less than the total gauge pressure measured in the packaging (i.e., the vapor pressure of the filling material and the partial pressure of the air or other inert gas minus 100 kPa (15 psi) at 55°C (131°F) and multiplied by a safety factor of 1.5. This total gauge pressure must be determined on the basis of a maximum degree of filling in accordance with § 173.24a(b)(3) of this subchapter and a filling temperature of 15°C (59°F);

(2) Not less than 1.75 times the vapor pressure at 50°C (122°F) of the material to be transported minus 100 kPa (15 psi) but with a minimum test pressure of 100 kPa (15 psi); or

(3) Not less than 1.5 times the vapor pressure at 55°C (131°F) of the material to be transported minus 100 kPa (15 psi), but with a minimum test pressure of 100 kPa (15 psi).

Packagings intended to contain hazardous materials of Packing Group I must be tested to a minimum test pressure of 250 kPa (36 psi).

(e) **Criteria for passing the test.** A package passes the hydrostatic test if, for each test sample, there is no leakage of liquid from the package.

1 Sec. 178.606 Stacking test.

(a) **General.** All packaging design types other than bags must be subjected to a stacking test.

(b) **Number of test samples.** Three test samples are required for each different packaging. For periodic retesting of packagings constructed of stainless steel, monel, or nickel, only one test sample is required. Exceptions for the number of aluminum and steel sample packagings used in conducting the stacking test are subject to the approval of the Associate Administrator of Hazardous Materials Safety. Notwithstanding the provisions of § 178.602(a) of this subpart, combination packagings maybe subjected to the stacking test without their inner packagings, except where this would invalidate the results of the test.

(c) **Test method-**

(1) **Design qualification testing.** The test sample must be subjected to a force applied to the top surface of the test sample equivalent to the total weight of identical packages which might be stacked on it during transport. The minimum height of the stack, including the test sample, must be 3.0 m (10 feet). The duration of the test must be 24 hours, except that plastic drums, jerricans, and composite packaging 6HH, intended for liquids, shall be subjected to the stacking test for a period of 28 days at a temperature of not less than 40°C (104°F). Alternative test methods which yield equivalent results may be used if approved by the Associate Administrator for Hazardous Materials Safety.

(2) **Periodic retesting.** The test sample must be tested in accordance with:

- (i) Section 178.606(c)(1) of this subpart; or
- (ii) The packaging may be tested using a dynamic compression testing machine. The test must be conducted at room temperature on an empty, unsealed packaging. The test sample must be centered on the bottom platen of the testing machine. The top platen must be lowered until it comes in contact with the test sample. Compression must be applied end to end. The speed of the compression tester must be one-half inch plus or minus one-fourth inch per minute. An initial preload of 50 pounds must be applied to ensure a definite contact between the test sample and the platens. The distance between the platens at this time must be recorded as zero deformation. The force to then be applied must be calculated using the formula:

Liquids: $A = (n-1) [w + (s \times v \times 8.3 \times .98)] \times 1.5;$

Solids: $A = (n-1) [w + (s \times v \times 8.3 \times .95)] \times 1.5;$

Where:

A = applied load in pounds

n = minimum number of containers that, when stacked, reach a height of 3 m

s = specific gravity of lading

w = maximum weight of one empty container in pounds

v = actual capacity of container (rated capacity +outage) in gallons

And:

8.3 corresponds to the weight in pounds of 1.0 gallon of water.

1.5 is a compensation factor that converts the static load of the stacking test into a load suitable for dynamic compression testing.

(d) **Criteria for passing the test.** No test sample may leak. In composite packagings or combination packagings, there must be no leakage of the filling substance from the inner receptacle, or inner packaging. No test sample may show any deterioration which could adversely affect transportation safety or any distortion likely to reduce its strength, cause instability in stacks of packages, or cause damage to inner packagings likely to reduce safety in transportation. Stacking stability is considered sufficient when, after the stacking test, and, in the case of plastic packagings after cooling to ambient temperature, two packagings of the same type filled with water placed on each test sample maintain their positions for one hour. For the dynamic compression test, a container passes the test if, after application of the required load, there is no buckling of the sidewalls sufficient to cause damage to its expected contents; in no case may the maximum deflection exceed one inch.

Sec. 178.607 Cooperage test for bung-type wooden barrels.

(a) **Number of samples.** One barrel is required for each different packaging.

(b) **Method of testing.** Remove all hoops above the bilge of an empty barrel at least two days old.

(c) **Criteria for passing the test.** A packaging passes the cooperage test only if the diameter of the cross-section of the upper part of the barrel does not increase by more than 10 percent.

1 Sec. 178.608 Vibration standard.

(a) Each packaging must be capable of withstanding, without rupture or leakage, the vibration test procedure outlined in this section.

(b) Test method.

(1) Three sample packagings, selected at random, must be filled and closed as for shipment.

(2) The three samples must be placed on a vibrating platform that has a vertical or rotary double-amplitude (peak-to-peak displacement) of one inch. The packages should be constrained horizontally to prevent them from falling off the platform, but must be left free to move vertically, bounce and rotate.

(3) The test must be performed for one hour at a frequency that causes the package to be raised from the vibrating platform to such a degree that a piece of material approximately 1.6 mm

(0.063 inch) thickness (such as steel strapping or paperboard) can be passed between the bottom of any package and the platform.

(4) Immediately following the period of vibration, each package must be removed from the platform, turned on its side and observed for any evidence of leakage.

(5) Other methods, at least equally effective, may be used. If approved by the Associate Administrator for Hazardous Materials Safety.

(c) **Criteria for passing the test.** A packaging passes the vibration test if there is no rupture or leakage from any of the packages. No test sample should show any deformation which could adversely affect transportation safety or any distortion liable to reduce packaging strength.

Sec. 178.609 Test requirements for packaging for infectious substances (etiologic agents).

(a) Samples of each packaging must be prepared for testing as described in paragraph (b) of this section and then subjected to the tests in paragraphs (d) through (i) of this section.

(b) Samples of each packaging must be prepared as for transport except that a liquid or solid infectious substance should be replaced by water or, where conditioning at -18°C (0°F) is specified, by water/antifreeze. Each primary receptacle must be filled to 98 percent capacity. Packagings for live animals should be tested with the live animal being replaced by an appropriate dummy of similar mass.

(c) Packagings prepared as for transport must be subjected to the tests in Table 1 of this paragraph, which, for test purposes, categorizes packagings according to their material characteristics. For outer packagings, the heading in Table 1 relate to fiberboard or similar materials whose performance may be rapidly affected by moisture; plastics, other than expanded plastics or film, which may embrittle at low temperature; and other materials such as metal whose performance is not significantly affected by moisture or temperature. Inner packagings may be of plastics, other than expanded plastics or film. Where a primary receptacle and a secondary packaging of an inner packaging are made of different materials, the material of the primary receptacle determines the appropriate test.

Table I: Tests Required

Material of					Tests Required				
outer packaging			inner packaging		Refer to para. (d)				Refer to para. (h)
Fiber-board	Plastics	Other	Plastics	Other	(d)	(e)	(f)	(g)	
X			X			X	X	When dry ice is used	X
X				X		X			X
	X		X	X			X		X
	X			X			X		X
		X	X	X	X		X		X

(d) Samples must be subjected to free-fall drops onto a rigid, non-resilient, flat, horizontal surface from a height of 9 m (30 feet). The drops must be performed as follows:

(1) Where the samples are in the shape of a box, five must be dropped in sequence:

- (i) Flat on the bottom;
- (ii) Flat on the top;
- (iii) Flat on the long side;
- (iv) Flat on the short side; and
- (v) On a corner.

(2) Where the samples are in the shape of a drum, three must be dropped in sequence:

- (i) Diagonally on the top chime, with the center of gravity directly above the point of impact;
- (ii) Diagonally on the base chime; and
- (iii) Flat on the side.

(3) While the sample should be released in the required orientation, it is accepted that for aerodynamic reasons the impact may not take place in that orientation.

(4) Following the appropriate drop sequence, there must be no leakage from the primary receptacle(s) which should remain protected by absorbent material in the secondary packaging.

(e) The sample must be fully immersed in water for a period of at least 5 minutes and then allowed to drain for not more than 30 minutes at 23°C (73°F) and 50 ± 2 percent relative humidity. It should then be subjected to the test described in paragraph (d) of this section.

(f) The sample must be conditioned in an atmosphere of -18°C (0°F) or less for a period of at least 24 hours and within 15 minutes of removal from that atmosphere be subjected to the test described in paragraph (d) of this section. Where the sample contains dry ice, the conditioning period may be reduced to 4 hours.

(g) Where packaging is intended to contain dry ice, a test additional to that specified in paragraph (d) or (e) or (f) of this section must be carried out. One sample must be stored so that all the dry ice dissipates and then be subjected to the test described in paragraph (d) of this section.

(h) Packagings with a gross mass of 7 kg (15 pounds) or less should be subjected to the tests described in paragraph (h)(1) of this section and packagings with a gross mass exceeding 7 kg (15 pounds) to tests in paragraph (h)(2) of this section.

(1) Samples must be placed on a level hard surface. A cylindrical steel rod with a mass of at least 7 kg (15 pounds), a diameter not exceeding 38 mm (1.5 inches) and the impact end edges a radius not exceeding 6 mm (0.2 inches), must be dropped in a vertical free fall from a height of 1 m (3 feet), measured from impact end of the impact surface of the sample. One sample must be placed on its base. A second sample must be placed in an orientation perpendicular to that used for the first. In each instance the steel rod must be aimed to impact the primary receptacle. Following each impact, penetration of the secondary packaging is acceptable, provided that there is no leakage from the primary receptacle(s).

(2) Samples must be dropped on to the end of a cylindrical steel rod. The rod must be set vertically in a level hard surface. It must have a diameter of 38 mm (1.5 inches) and the edges of the upper end radius not exceeding 6 mm (0.2 inches). The rod must protrude from the surface a distance at least equal to that between the primary receptacle(s) and the outer surface of the outer packaging with a minimum of 200 mm (7.9 inches). One sample must be dropped in a vertical free fall from a height of 1 m (3 feet), measured from the top of the steel rod. A second sample must be dropped from the same height in an orientation perpendicular to that used for the first. In each instance the packaging should be so orientated that the steel rod must be aimed to impact the primary receptacle(s). Following each impact, penetration of the secondary packaging is acceptable, provided that there is not leakage from the primary receptacle(s).

APPENDICES TO PART 178

Appendix A - Specifications for Steel

Table 1

Open-hearth, basic oxygen, or electric steel of uniform quality.

The following chemical composition limits are based on ladle analysis:

Designation	Chemical composition, percent-ladle analysis		
	Grade 1 ¹	Grade 2 ^{1,1}	Grade 3 ^{2,4,5}
Carbon	0.10/0.20	0.24 maximum	0.22 maximum
Manganese	1.10/1.60	0.50/1.00	1.25 maximum
Phosphorus, maximum	0.04	0.04	0.0456
Sulfur, maximum	0.05	0.05	0.05
Silicon	0.15/0.30	0.30 maximum	
Copper, maximum	0.40		
Columbium		0.01/0.04	
Heat treatment authorized	(³)	(³)	(³)
Maximum stress (p.s.i.)	35,000	35,000	35,000
¹ Addition of other elements to obtain alloying effect is not authorized. ² Ferritic grain size 6 or finer according to ASTM E 112-63. ³ Any suitable heat treatment in excess of 1,100° F., except that liquid quenching is not permitted. ⁴ Other alloying elements may be added and shall be reported. ⁵ For compositions with a maximum carbon content of 0.15 percent on ladle analysis, the maximum limit for manganese on ladle analysis may be 1.40 percent. ⁶ Rephosphorizing Grade 3 steels containing no more than 0.15 percent phosphorus are permitted if carbon content does not exceed 0.15 percent and manganese does not exceed 1 percent.			

Check Analysis Tolerances

A heat of steel made under any of the above grades, the ladle analysis of which is slightly out of the specified range, is acceptable if the check analysis is with the following variations:

Element	Limit or maximum specified (percent)	Tolerance (percent) over the maximum limit or under the minimum limit	
		Under minimum limit	Over minimum limit
Carbon.....	To 0.15 inclusive	0.02	0.03
	Over 0.15 to 0.40 inclusive	0.03	0.04
Manganese.....	To 0.60 to 1.5 inclusive	0.03	0.03
	Over 0.60 to 1.5 inclusive	0.04	0.04
	Over 1.15 to 2.50 inclusive	0.05	0.05
Phosphorous ⁷	All ranges	0.01
Sulfur	All ranges	0.01
Silicon.....	To 0.30 inclusive	0.02	0.03
	Over 0.30 to 1.00 inclusive	0.05	0.05
Copper.....	To 1.00 inclusive	0.03	0.03
	Over 1.00 to 2.00 inclusive	0.05	0.05
Nickel.....	To 1.00 inclusive	0.03	0.03
	Over 1.00 to 2.00 inclusive	0.05	0.05
Chromium.....	To 0.90 inclusive	0.03	0.03
	Over 0.90 to 2.10 inclusive	0.05	0.05
Molybdenum.....	To 0.20 inclusive	0.01	0.01
	Over 0.20 to 0.40 inclusive	0.02	0.02
Zirconium.....	All ranges	0.01	0.05
Columbium	To 0.04 inclusive	0.005	0.01
Aluminum	Over 0.10 to 0.20 inclusive	0.04	0.04
	Over 0.20 to 0.30 inclusive	0.05	0.05

⁷ Rephosphorized steels not subject to check analysis for phosphorus.

1 Appendix B - Alternative Leakproofness Test Methods

In addition to the method prescribed in 178.604 of the subchapter, the following leakproofness test methods are authorized:

(1) **Helium test.** The packaging must be filled with at least 1 L inert helium gas, air tight closed, and placed in a testing chamber. The testing chamber must be evacuated down to a pressure of 5 kPa which equals an over-pressure inside the packaging of 95 kPa. The air in the testing chamber must be analyzed for traces of helium gas by means of a mass spectrograph. The test must be conducted for a period of time sufficient to evacuate the chamber and to determine if there is leakage into or out of the packaging. If helium gas is detected, the leaking packaging must be automatically separated from non-leaking packagings and the leaking area determined according to the method prescribed in 178.604(d) of the subchapter. A packaging passes the test if there is no leakage of helium.

(2) **Pressure differential test.** The packaging shall be restrained while either pressure or a vacuum is applied internally. The packaging must be pressurized to the pressure required by 178.604(e) of this subchapter for the appropriate packing group. The method of restraint must not affect the results of the test. The test must be conducted for a period of time sufficient to appropriately pressurize or evacuate the interior of the packaging and to determine if there is leakage into or out of the packaging. A packaging passes the pressure differential test if there is no change in measured internal pressure.

(3) **Solution over seams.** The packaging must be restrained while an internal air pressure is applied; the method of restraint may not affect the results of the test. The exterior surface of all seams and welds must be coated with a solution of soap suds or a water and oil mixture. The test must be conducted for a period of time sufficient to pressurize the interior of the packaging to the specified air pressure and to determine if there is leakage of air from the packaging. A packaging passes the test if there is no leakage of air from the packaging.

(4) **Solution over partial seams test.** For drums, the following test may be used: The packaging must be restrained while an internal air pressure of 48 kPa (7.0 psig) is applied; the method of restraint may not affect the results of the test. The packaging must be coated with a soap solution over the entire side seam and a distance of not less than eight inches on each side of the side seam along the chime seam(s). The test must be conducted for a period of time sufficient to pressurize the interior of the packaging to the specified air pressure and to determine if there is leakage of air from the packaging. A packaging passes the test if there is no leakage of air from the packaging. Chime cuts must be made on the initial drum at the beginning of each production run and on the initial drum after any adjustment to the chime seamer. Chime cuts must be maintained on file in date order for not less than six months and be made available to a representative of the Department of Transportation on request.